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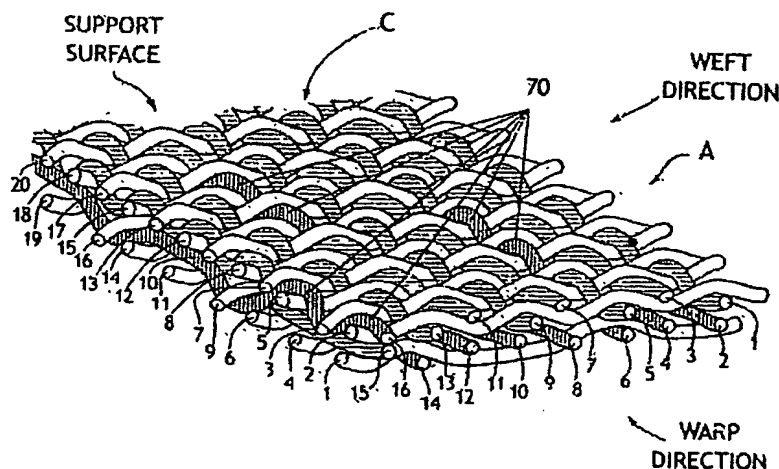
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ning of each regular issue of the PCT Gazette.

(54) Title: WARP BOUND COMPOSITE PAPERMAKING FABRIC



(57) Abstract: A composite papermaking fabric comprising an upper support fabric and a lower contact fabric. The upper fabric is formed of warp yarns, fabric born warp yarns and weft yarns interwoven to provide the upper fabric with a support surface forming a one up, one down weave. The lower fabric is formed of the fabric born warp yarns interwoven with weft yarns in a weave pattern which provides a weft yarn dominated contact surface. Each of the fabric born warp yarns also weaves over at least one of the upper fabric weft yarns during each repeat of the weave pattern forming binding points which bind the upper and lower fabrics together.

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## 5                    **WARP BOUND COMPOSITE PAPERMAKING FABRIC**

### **Background of the Invention**

The present invention is directed to a composite papermaking fabric which is preferably used in the forming section but could also be used in the dryer section. The term composite fabric refers to a fabric comprising two woven structures one of which is the paper side fabric or upper fabric and the other of which is the machine side fabric or lower fabric. The paper side fabric includes a support surface which surface receives and supports the paper forming pulp during the paper forming operation. The lower or contact fabric separates the support fabric from the machine rollers during the paper forming operation and includes a roller contact or contact surface. Both fabrics must be stable and provide the required drainage. The support fabric must also provide an even support surface without unduly high knuckles or unduly deep knuckle depressions so as to not mark the paper during the paper forming operation.

20            The upper and lower fabrics are bound together with a binder yarn which in the instant case comprises fabric born warp yarn. The term fabric born warp yarn indicates that the binder yarn while binding the upper and lower fabrics together also weaves in the machine direction with and is an integral part of the weave pattern of both the upper and lower fabrics. The term warp yarn refers to yarns which weave in a single specified layer of the fabric and in the machine direction. The term weft yarn refers to  
25            yarns woven transverse of the warp yarns.

Composite papermaking fabrics are well known as are illustrated by the U.S.

5 Patents 5,152,326; 5,826,627; 6,202,705; and 6,240,973.

It is an object of the present invention to provide a composite papermaking fabric which provides uniform drainage, a smooth and even support surface and extended wear.

Another object of the invention is a papermaking fabric in which the support  
10 surface is formed in a one up, one down weave pattern.

Another object of the invention is a composite papermaking fabric in which fabric born warp yarns bind the upper and lower fabrics together and weave with weft yarns to form the lower fabric.

Another object of the invention is a composite papermaking fabric in which the  
15 weft yarn of the upper fabric at the binding points are supported against downward movement.

Another object of the invention is the provision of a composite papermaking fabric in which no pairing of weft yarns appear on either surface.

Another object of the invention is the provision of a composite papermaking  
20 fabric in which no pairing of warp and fabric born warp yarns appear on either surface.

#### **Summary of the Invention**

The present invention is directed to a composite papermaking fabric having an  
25 upper fabric which includes a fiber support surface and is formed of warp yarns, fabric born warp yarns and weft yarns. The support surface is woven in a one up, one down

5    weave pattern. The papermaking fabric also includes a lower fabric formed of fabric  
born warp yarns and weft yarns interwoven to provide a weft yarn dominated contact  
surface. Each fabric born warp yarn is controlled to weave over at least one of the  
upper fabric weft yarns during each repeat of the weave pattern forming binding points  
which act to bind the upper fabric with the lower fabric.

10        The preferred weave pattern requires that each fabric born warp yarn weave  
over two of the upper weft yarns to form two binding points which are spaced  
longitudinally of the weave pattern. The binding points preferably form a broken twill  
line across the weave pattern and the width of the papermaking fabric. But it is also  
possible that the binding points form a straight twill line across the paperside weave  
15    pattern.

To insure that the support surface is even and smooth, the upper warp yarns  
float beneath the upper weft yarns at each of the binding points forming a support  
beneath the upper weft yarns which acts to maintain knuckle height uniform across the  
support surface. The fabric born warp yarns weave with the weft yarns of the lower  
20    fabric in preferably a broken twill pattern forming a plurality of even weft floats on the  
contact surface. There is a plurality of the weft yarn floats formed by each lower weft  
yarn per weave pattern repeat.

A composite papermaking fabric comprising an upper fabric formed with a  
support surface woven in a one up, one down weave pattern and a lower fabric formed  
25    with a weft dominated contact surface. The papermaking fabric comprises a plurality

5 of warp yarns weaving with upper weft yarns in a selected first weave pattern and a plurality of fabric born warp yarns weaving with lower weft yarns in a selected second weave pattern forming the lower fabric and weaving with the upper weft yarns in the second selected weave pattern to cross over the upper weft yarns at selected locations forming binding knuckles. The fabric born warp yarns at the binding knuckles bind the  
10 upper fabric with the lower fabric. The binding knuckles cooperate with the knuckles of the warp yarns weaving in the first weave pattern to form the support surface in a one up, one down weave pattern.

The warp yarns weave beneath each of the upper weft yarn at the selected locations forming the binding knuckles providing support beneath the upper weft yarn  
15 and the binding knuckle which support assists in maintaining the binding knuckles parallel with the remainder of the knuckles of the support surface.

The weft yarn weaving with the fabric born warp yarns form the contact surface with two floats on the contact surface per pick throughout a weave pattern repeat.

20

### Drawings

Fig 1 is a cutaway perspective view showing the support surface of the papermaking fabric through a portion of the weave pattern.

Fig 2 is a cutaway perspective view showing the contact surface of the papermaking fabric through a portion of the weave pattern.

5           Fig 3 is a side view showing the relationship of warp yarn 1 and fabric born warp yarn 2 with all of the weft yarns through the weave pattern.

          Fig 4 is similar to Fig 3 showing the relationship of warp yarn 3 and fabric born warp yarn 4 with the weft yarns through the weave pattern.

          Fig 5 is similar to Fig 3 showing the relationship of warp yarn 5 and fabric born  
10   warp yarn 6 with the weft yarns through the weave pattern.

          Fig 6 is similar to Fig 3 showing the relationship of warp yarn 7 and fabric born warp yarn 8 with the weft yarns through the weave pattern.

          Fig 7 is similar to Fig 3 showing the relationship of warp yarn 9 and fabric born warp yarn 10 with the weft yarns through the weave pattern.

15           Fig 8 is similar to Fig 3 showing the relationship of warp yarn 11 and fabric born warp yarn 12 with the weft yarns through the weave pattern.

          Fig 9 is similar to Fig 3 showing the relationship of warp yarn 13 and fabric born warp yarn 14 with the weft yarns through the weave pattern.

          Fig 10 is similar to Fig 3 showing the relationship of warp yarn 15 and fabric  
20   born warp yarn 16 with the weft yarns through the weave pattern.

          Fig 11 is a diagram of the weave pattern of the support surface.

          Fig 12 is a diagram of the weave pattern of the contact surface.

#### **Detailed Description**

5           Turning now to the drawings Figs 1 and 2 represent sectional perspective views of the composite papermaking in which the upper fabric A is formed with a paper pulp support surface C as shown in Fig 1 and the lower contact fabric B which is formed with a lower roller contact surface D as shown in Fig 2. As shown in Fig 1 and further illustrated in Fig 11, upper fabric A and more specifically, support surface C is woven  
10 in a one up, one down weave pattern allowing the support surface to present an even array of warp knuckles separated on each side by a weft knuckle. This is best illustrated in Fig 11 where each O represents a warp yarn passing over a weft yarn on the support surface. Each passover forms a warp knuckle. Likewise, each weft yarn passing over a warp yarn on the support surface is represented by a blank square.  
15 These passovers form weft knuckles. Each O represents a binding point where the warp yarn passing over the weft yarn is an fabric born warp yarn.

          The fabric is woven utilizing eight warp yarns numbered 1, 3, 5, 7, 9, 11, 13 & 15 and with eight fabric born warp yarns numbered 2, 4, 6, 8, 10, 12 & 16 per weave pattern repeat which is a so called 16 shaft weave. The present invention is not limited  
20 to the weave repeat shown in the figures. It's understood that the weave repeat in general can be 16 shaft or greater. Therefore the weave repeat could be for example a 20 shaft or a 24 shaft or a 28 shaft or a 32 shaft or a 40 shaft weave. The weave pattern repeat also weaves with forty weft yarns numbered 1-40. Weft yarns 2, 3, 5, 7, 8, 10, 11, 12, 13, 15, 17, 18, 20, 22, 23, 25, 27, 28, 30, 32, 33, 35, 37, 38 & 40  
25 weave with the warp yarns and the fabric born warp yarns to form the upper or support

5 fabric A. Weft yarns 1, 4, 6, 9, 11, 14, 16, 19, 21, 24, 26, 29, 31, 34, 36 & 39 weave only with the fabric born warp yarn to form lower or contact fabric B.

Again turning to Figs 1, 2, 11 & 12. In Figs 1 & 11, the x represents the binding points or the positions in which an fabric born warp yarn passes over an upper weft yarn weaving with the support fabric A to bind the support fabric A with the contact  
10 fabric B forming the composite fabric. These binding points, which form binding knuckles 70, are identified in Figs 1 and 3-10.

Figs 3-10 are side views of each of the warp and fabric born warp yarns weaving with the weft yarns 1-40 through a complete repeat of the weave pattern. As can be seen in Figs 3 - 10 the ratio of upper weft yarns to lower weft yarns is 3 : 2. It  
15 is understood that this ratio is not limiting the scope of the invention, therefore the ratio exemplary also could be 2 : 1 or 5 : 3. As is clearly shown, warp yarns 1, 3, 5, 7, 9, 11, 13 & 15 weave only with weft yarns 2, 3, 5, 7, 8, 10, 12, 13, 15, 17, 18, 20, 22, 23, 25, 27, 28, 30, 32, 33, 35, 37, 38 & 40 forming support fabric A. The weave pattern at selected points brings the upper warp yarns to float beneath five consecutive of the  
20 upper weft yarn picks, such as warp yarn 1 at the pick of weft yarns 15, 17, 18, 20 & 22 in Fig 3 and warp yarn 5 at the pick of weft yarns 5, 7, 8, 10 and 12 in Fig 5. It is along these floats that the fabric born warp yarns are brought up to pass over two spaced picks, such as fabric born warp yarn 2 over picks 17 & 20 in Fig 3 and fabric born warp yarn 6 over picks 7 and 10 in Fig 5, binding upper fabric A with lower fabric  
25 B. Throughout the remainder of the weave pattern, each of the fabric born warp yarns



5 weaves with selected of the upper weft yarns securing support fabric A with contact fabric B at the binding points illustrated in Fig 11 along each fabric born warp yarn. The binding points form a broken twill pattern over the support surface. It has to be stated that the weave pattern of the support fabric A predominantly is created by the weaving of the warp yarns 1, 3, 5, 7, ... with the upper (paper side) weft yarns 2, 3, 5, 10 7, 8, 10, 11, 12, 13, 15, 17, 18, 20, 22, 23, 25, 27, 28, 30, 32, 33, 35, 37, 38 & 40 and that the weaving of the fabric born warp yarns 2, 4, 6, 8, 10, 12 & 16 with the (paper : side) weft yarns gives a minor contribution to the weave pattern of the support fabric A. It can be stated that for the composite papermaking fabric according to the invention the warp yarns weave during each repeat of said weave pattern with a predominant or 15 major portion of the upper weft yarns and that the fabric born warp yarns weave only with a minor portion of the upper weft yarns to form the upper fabric weave pattern. It is to be understood that a major portion means a portion of more that 50% and a minor portion means a portion of less than 50%.

20 By way of example as can be seen in Fig 3 warp yarn 1 weaves with upper (paper side) weft yarns 2, 3, 5, 7, 8, 10, 12, 13, 15, 22, 23, 25, 27, 28, 30, 32, 33, 35, 37, 38 & 40 a one up, one down weave pattern and floats beneath the upper (paper side) weft yarns 17, 18, 20. The weave pattern of the support fabric A is completed by the weaving of the fabric born warp yarn 2 with the weft yarns 17, 18, 20.

5           In the weave pattern shown in Fig 3 warp yarn 1 weaves with seven times more (paper side) wefts than fabric born warp yarn 2.

          Again, as seen in Figs 1 & 3-10 at each binding point 70, the associated upper warp yarn passes beneath the pick where the binding point is formed with the fabric born warp yarn. In the above referred to example, warp 1 passes beneath weft yarn  
10 or picks 17 & 20 at binding points 70. Likewise in Fig 5 warp yarn or pick 5 passes beneath weft yarns 7 & 10 at binding point 70. By so controlling the upper warp yarns to be positioned beneath the binding points 70 they function to support the weft yarns and thereby the binding knuckles against vertical downward movement. As described previously the weave pattern of the support fabric A predominantly is formed by the  
15 weaving of the warp yarns 2, 3, 5, 7, 8, 10, 11 ... In advanced studies applicant in general came to the conclusion that for creating a smooth and uniform support surface C it is necessary that the upper (paper side) weft yarns which interweave with fabric born warp yarns or warp yarns and thereby only form a minor portion of the support fabric A need to be supported against vertical downward movement. Therefore, e.g.  
20 warp yarn 1 floats beneath (paper side) weft yarns 17, 18 & 20. This vertical support acts to help maintain the crest of the knuckles formed at binding points 70 elevated and on an even and substantially parallel plane with the remainder of the knuckles forming the support surface C. Also, by passing the upper warp yarns beneath the upper weft at the binding points no adjacent knuckles appear on the support surface at the binding  
25 points.

5           Turning now to Figs 2-10 & 12 contact fabric B will now be discussed. As seen  
In Figs 2 & 12 contact fabric B is woven in a broken twill pattern with each fabric born  
warp yarn passing beneath four weft yarns at spaced locations on contact surface D.  
Each fabric born warp yarn either floats above the lower weft yarns and beneath the  
warp and weft yarns of the upper or support fabric A or passes over the two of the  
10   upper picks forming binding points 70 throughout the remainder of each weave pattern  
as earlier discussed.

Turning again to Figs 2 & 12 it can be seen that the weave pattern forming lower  
fabric B produces a weft dominated contact surface D with each weft weaving with the  
lower fabric warp yarns to form two floats per pick throughout the weave pattern each  
15   of which passes beneath three warp yarns. This weave pattern forms a weft yarn  
dominated running or contact surface D.

The yarns selected for forming the disclosed may comprise yarns of the same  
diameter or of varying diameters if desired. For example, it may be desirable to weave  
the support fabric with weft yarns of less size than the weft yarns forming the contact  
20   fabric. The warp and the fabric born warp yarns preferably are of the same size.  
Variation in yarn size may be selected depending upon the performance requirements.

The materials chosen for the yarns can vary depending upon the performance  
needs of the formed papermaking fabric. Generally stability is of the utmost  
importance, it being desired that the drainage capability be maintained throughout the  
25   life of the papermaking fabric. Also, wearability is another vital factor due to cost.

5   Accordingly, polyester yarns which exhibit excellent stability characteristics may be selected to form the support surface and as the fabric born warp yarns. The running or contact surface weft yarns may all or partly be polyamide yarns due to greater wearability characteristics. Also, the contact side weft yarns may be of a larger diameter than the support fabric weft yarns. Other synthetic materials and size  
10 combinations may be selected to form the warp, weft, and fabric born warp yarns of the invention dependent upon the required performance needs of the fabric.

5           What is claimed is:

1.       A composite papermaking fabric comprising:

          an upper fabric formed of warp yarns, fabric born warp yarns and upper weft yarns interwoven to provide a support surface formed in a one up, one down weave pattern;

10           a lower fabric formed of fabric born warp yarns and lower weft yarns interwoven to provide a weft yarn dominated contact surface;

          each said fabric born warp yarn weaving over at least one of said upper weft yarns during each repeat of said weave pattern forming binding points binding said upper fabric with said lower fabric.

15           2.       The composite papermaking fabric of claim 1, wherein said warp yarns weave during each repeat of said weave pattern with a major portion of said upper weft yarns and wherein said fabric born warp yarns weave only with a minor portion of said upper weft yarns to form the upper fabric weave pattern.

          3.       The composite papermaking fabric of claim 1 or claim 2 wherein each  
20       said fabric born warp yarn weaves over at least two of said upper weft yarns forming two binding points spaced longitudinally of said weave pattern.

          4.       The composite papermaking fabric of any preceding claim wherein said binding points form a broken twill line across said weave pattern.

          5.       The composite papermaking fabric of any preceding claim wherein said  
25       upper warp yarns float beneath said upper weft yarns at said binding points forming

5 supports for said weft yarns at said binding points which act to maintain knuckle height uniform across said support surface.

6. The composite papermaking fabric of any preceding claim wherein said fabric born warp yarns weave with said weft yarns of said lower fabric in a broken twill pattern forming a plurality of weft yarns float on the contact surface,

10 7. The composite papermaking fabric of claim 6 wherein there are a plurality of said weft floats per lower fabric weft yarn per weave pattern repeat.

8. The composite papermaking fabric of any preceding claim, wherein said weave pattern comprises equal numbers of said warp yarns and said fabric born warp yarns.

15 9. The composite papermaking fabric of any preceding claim wherein said weave pattern comprises eight of said warp yarns, eight of said fabric born warp yarns and forty of said weft yarns per weave pattern repeat.

10. The composite papermaking fabric of any preceding claim wherein the ratio of upper weft yarns to lower weft is 2 : 1 or 3 : 2 or 5 : 3.

20 11. The composite papermaking fabric of any preceding claim wherein the weave repeat is at least 16 shaft weave repeat.

12. A composite papermaking fabric comprising an upper fabric formed with a support surface woven in a one up, one down weave pattern and a lower fabric formed with a weft dominated contact surface;

25 a plurality of warp yarns weaving with upper weft yarns in a selected first

5    weave pattern forming warp knuckles over said support surface;

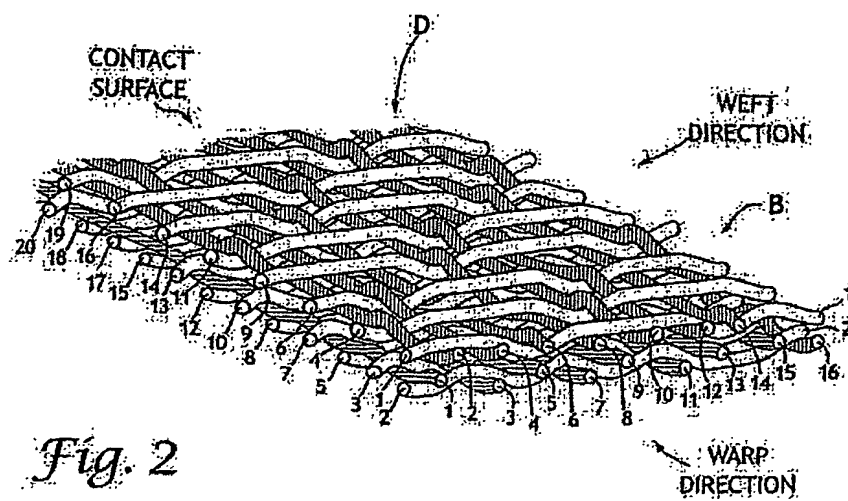
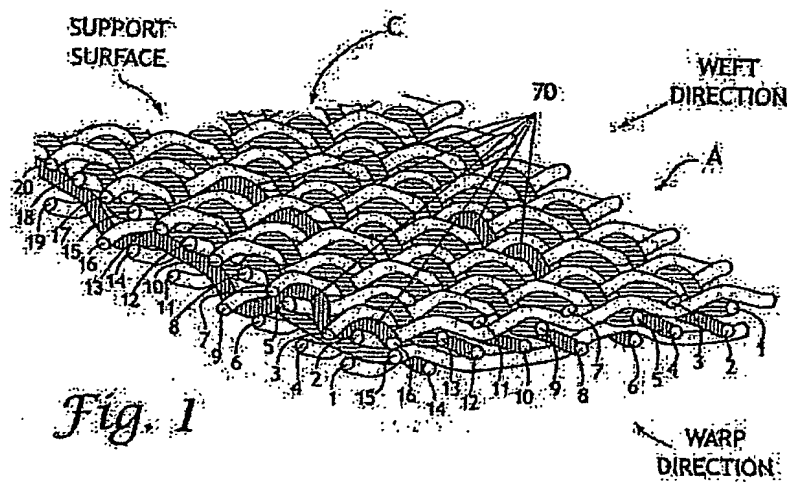
        a plurality of fabric born warp yarns weaving with lower weft yarns and said upper weft yarns in a selected second weave pattern;

        said fabric born warp yarns and said lower weft yarns forming said lower fabric and said fabric born warp yarns and said upper weft yarns forming binding knuckles  
10    with said upper weft yarns at selected locations over said support surface, said binding knuckles binding said upper fabric with said lower fabric; and said binding knuckles cooperating with said warp knuckles of said support surface to form said support surface with said one up, one down weave pattern.

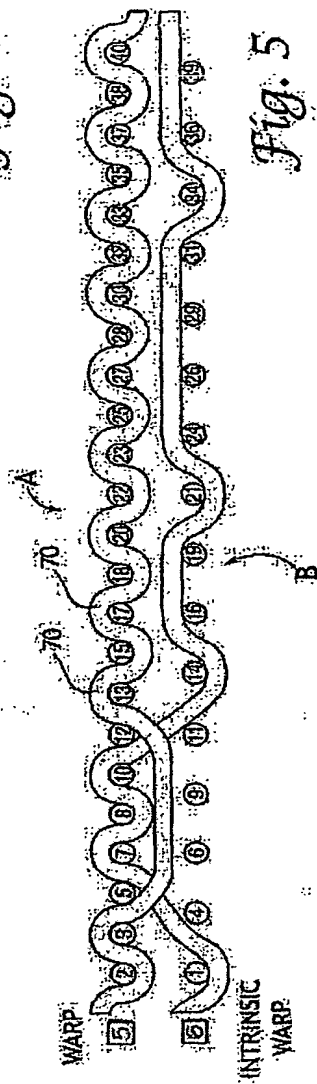
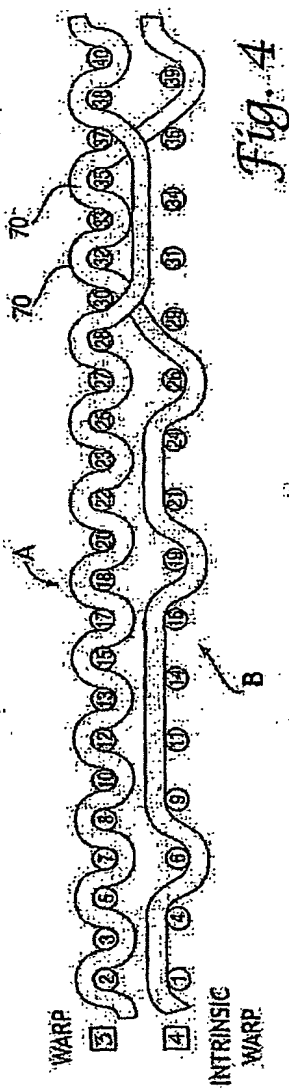
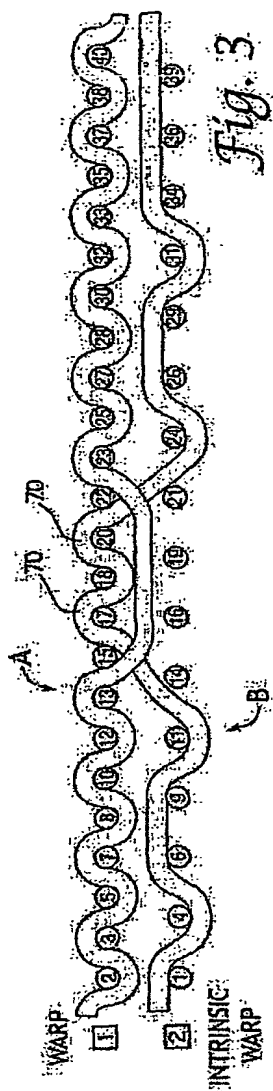
        13.    The composite papermaking fabric of claim 13 wherein said warp yarns  
15    weave beneath each said upper weft yarn at each of said selected locations beneath providing vertical support for said upper weft yarn and said binding knuckle.

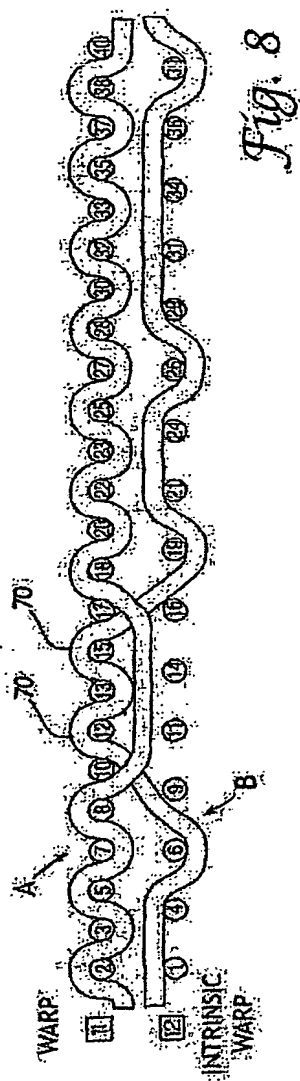
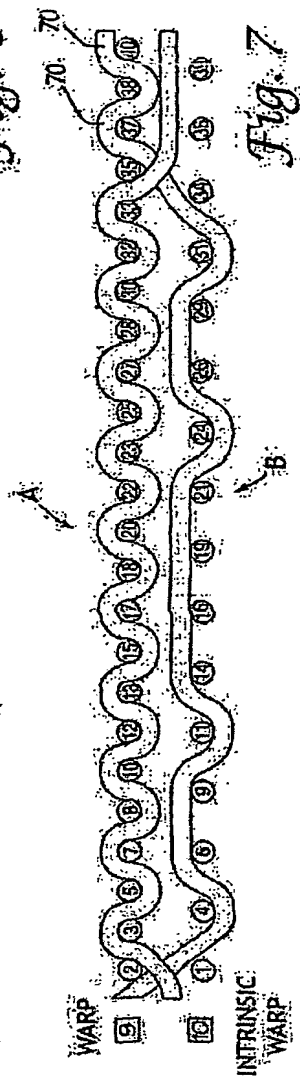
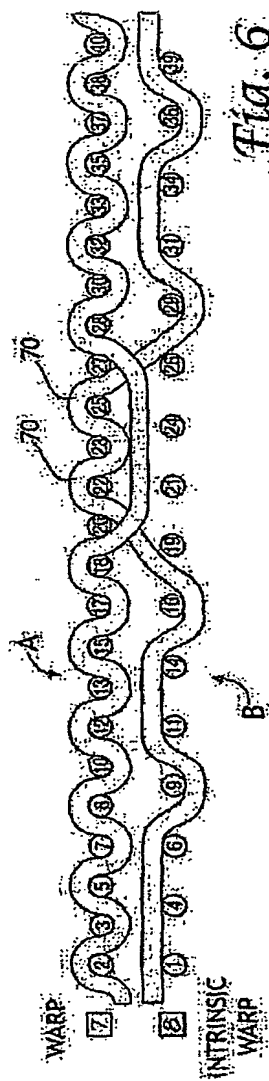
        14.    The composite papermaking fabric of claim 13 or claim 14 wherein said weft yarn of said contact surface form two floats per pick per weave pattern repeat.

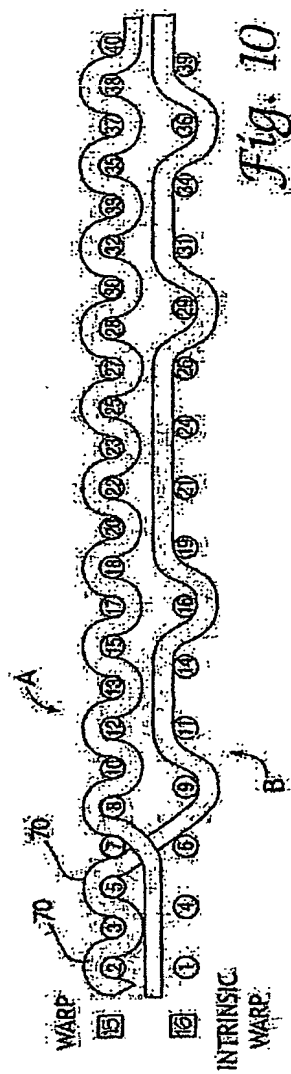
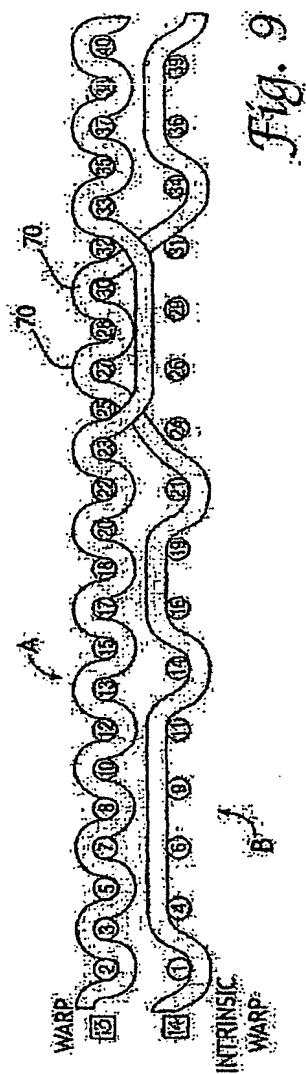
        15.    The composite papermaking fabric of any preceding claim wherein the  
20    wearside fully or partially consists of wear resistant yarns.











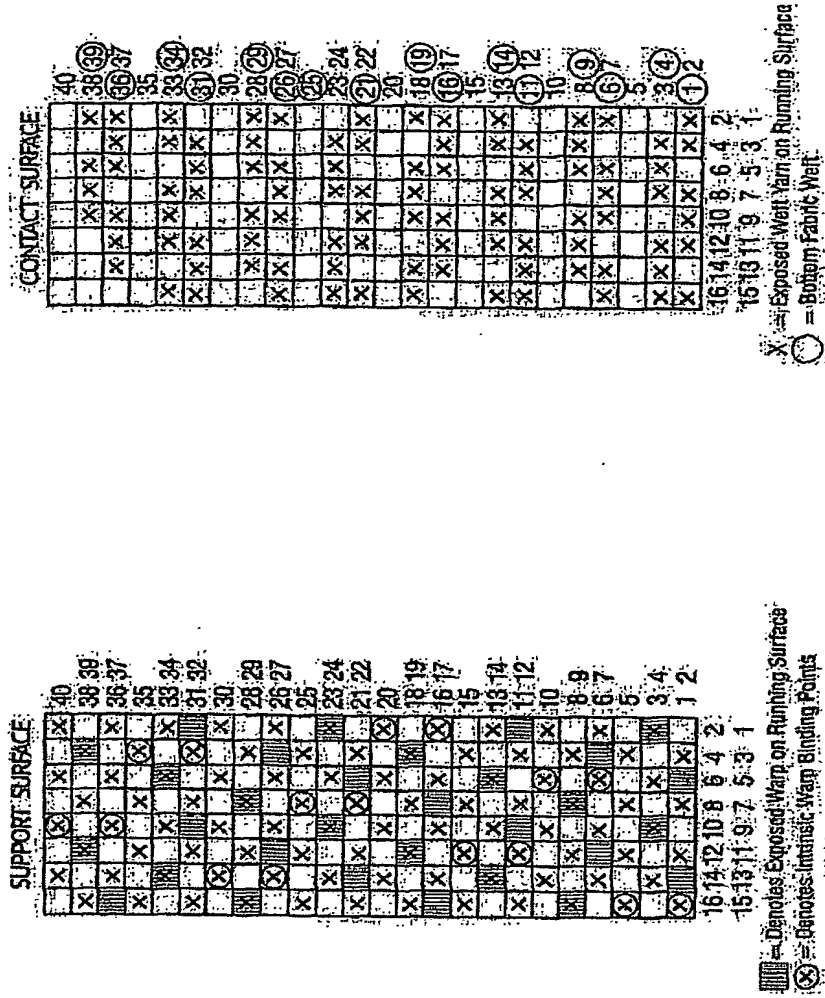


Fig. 11

Fig. 12

# INTERNATIONAL SEARCH REPORT

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## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 D21F1/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EP0-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 152 326 A (VOEHRINGER FRITZ) 6 October 1992 (1992-10-06) cited in the application column 4, line 48 - column 5, line 63; figures 2-5 -----	1,12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

22 November 2004

Date of mailing of the international search report

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Patent document cited in search report		Publication date		Patent family member(s)	Publication date
US 5152326	A	06-10-1992	DE	3938159 A1	23-05-1991
			AT	107979 T	15-07-1994
			DE	59006308 D1	04-08-1994
			EP	0432413 A1	19-06-1991
			ES	2057318 T3	16-10-1994
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